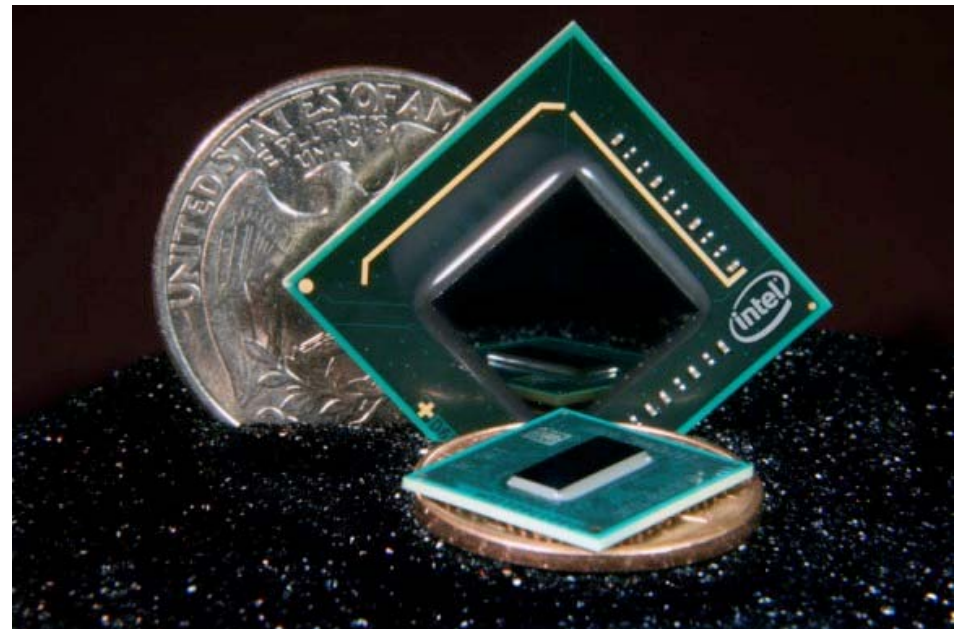


# Intel Atom Processor

Michelle McDaniel and Jonathan Dorn

# Introduction

- Completely new microarchitecture with very little in common with other Intel PC processors
- Designed with 3 primary goals:
  - Dramatically reduce power consumption
  - Sufficient performance for a full internet experience
  - Full x86 compatibility



# Markets

- Low-cost subnotebook computers (netbooks)
- Low-cost desktop PCs (nettops)
- Mobile internet devices (MIDs)
  - Handheld computers with wireless internet connectivity but without conventional keyboards

# Silverthorne

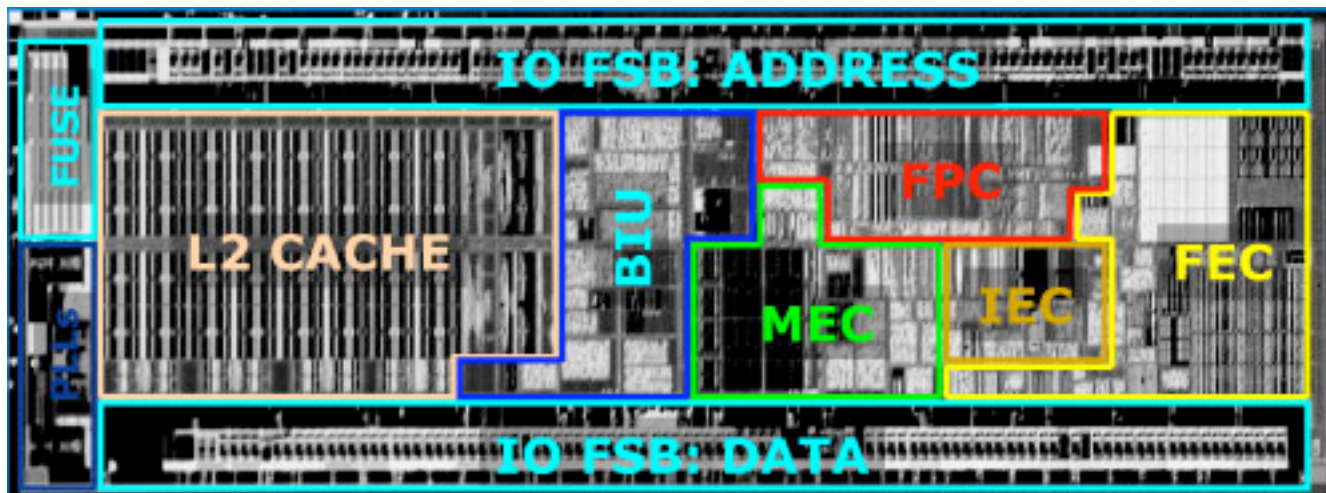
(2008, MID market)

Feature	Intel Atom Z500	Intel Atom Z510	Intel Atom Z530	Intel Atom Z540	Pentium M ULV 733J
Core freq	800MHz	1.1GHz	1.60GHz	1.8GHz	1.1GHz
FSB Freq	400MHz	400MHz	533MHz	533MHz	400MT/s
Hyper-threads	2	2	2	2	1
TDP	650mW	2.0W	2.0W	2.4W	5W
Avg Power	160mW	220mW	220mW	220mW	
Voltage	0.80V-1.1V	0.75V-1.1V	0.75V-1.1V	0.75V-1.1V	0.81-0.96V
Die Size	26mm <sup>2</sup>	26mm <sup>2</sup>	26mm <sup>2</sup>	26mm <sup>2</sup>	87mm <sup>2</sup>
Instructions	32bit	32bit	32bit	32bit	32bit

Adapted from: T.R. Halfhill, "Intel's Tiny Atom," *Microprocessor Report*, 7 April 2008.

# Memory Hierarchy

- L1 Cache:
  - 36K Instruction cache; only 32K available for use
  - 24K Data cache
  - Instruction and data cache have only 1 read port and 1 write port each
- 512K L2 Cache





# Low Power Philosophy



- Target: 90% lower power than 90nm Pentium M (Dothan)
- Discard previous x86 microarchitectures
  - Too heavyweight; too power-hungry
  - Start with simple design and add capabilities
- Additional features must provide 1% performance for 1% power
  - Reject anything requiring 2-3% power increase for 1% performance gain



# Atom Design Decisions

## Discarding Previous Microarchitectures



- No out-of-order processing
  - Too much logic to shuffle instructions
  - Not enough benefit for the power required
- No aggressive speculation
- No x86 instruction transformation (micro-ops)
  - Almost: the most complicated instructions are still split into multiple instructions, executed in parallel



# Atom Design Decisions

## Low-Power Performance

- 45nm technology
- In-order, dual-issue 16-stage instruction pipeline with a second integer pipe
- Two instruction decoders
  - Finding variable-length instruction boundaries takes up to 3 cycles.
  - Instruction cache marks ends of instructions.
  - Hits in the I-cache can skip these extra cycles.



# Atom Design Decisions

## Hyper-Threading

- 2-way SMT
- Boosts performance by 36-47%
- Increases power consumption by 17-19%
  - Hyper-threading requires more logic and an extra register file, resulting in more power consumption
- Increases die area by 8%
- Major bang for the power and area cost



# Atom Design Decisions

## Programmable features



- Number of outstanding I/O requests buffered on the FSB
- Parts of the L2 cache can be shut down
- Set-associativity programmable, from 2 to 8 ways
- Enhanced Speed-Step technology

# Atom Design Decisions


## Power States

- Multiple x86 power states
- From full power (C0) to deep-sleep (C6)
- C6 uses 1.6% of TDP
  - When entering C6 mode
    - Processor saves all state information, stops the clocks and shuts down FSB, goes to sleep
  - Coming Back
    - Restart clocks, restore state information, reprime pipeline
    - Atom gradually refills caches on demand to conserve power
  - Can switch from C6 to C0 in less than 100 microseconds



# Atom Design Decisions

## Dark Silicon?

- 
- Modular microarchitecture
  - Can disable 64-bit x86 extensions, virtualization extensions, Hyper-threading
  - Can offer chips with either CMOS transceiver logic or Advanced Gunning Transceiver Logic; both are built into the chip

# Notable Features

Feature	Intel Atom Z560	Intel Atom N270	Intel Atom N475	Intel Atom D525	Intel Core i7-610E
Core freq	2.13GHz	1.6GHz	1.83GHz	1.8GHz	2.53GHz
FSB Freq	533MHz	533MHz	DMI	533MHz	DMI
Cores	1	1	1	2	2
Hyper-threads	2	2	2	2 per core	2 per core
TDP	2.5W	2.5W	6.5W	13W	35W
Voltage	0.75V-1.1V	0.9V-1.16V	0.8V-1.18V	0.8V-1.18V	0.775–1.4 V
Die Size	26mm <sup>2</sup>	26mm <sup>2</sup>	66mm <sup>2</sup>	87mm <sup>2</sup>	81 mm <sup>2</sup>
Instructions	32bit	32bit	64bit	64bit	64bit

<http://www.intel.com/products/processor/atom/specifications.htm>

# Outstanding Questions

- How much MID market penetration does the Atom have?
- All of the netbooks being shipped with the Atom ship with 32-bit operating systems (as far as we have been able to determine), so why is the Atom 64-bit compatible?
- Since the Atom's intended workload is internet-based, are 64-bit capabilities necessary?



# Further Reading



- T. R. Halfhill, “Intel’s Tiny Atom,” *Microprocessor Report*, 7 April 2008.
- B. Beavers, “The Story Behind the Intel Atom Processor Success,” *IEEE Design & Test of Computers*, March-April 2009.



Questions?

